Operational and Safety Effects of Alternative Median Treatments

Background

❶ NCHRP Project 3-49
"Capacity and Operational Effects of Midblock Left-turn Lanes"

❷ Operation, Safety, & Access

❸ Raised-Curb Median
Two-Way Left-Turn Lane
Undivided Cross Section

Overview

Traffic Operations

1. Effect of median treatment
2. Operations Model

Traffic Safety

3. Effect of median treatment
4. Safety Model

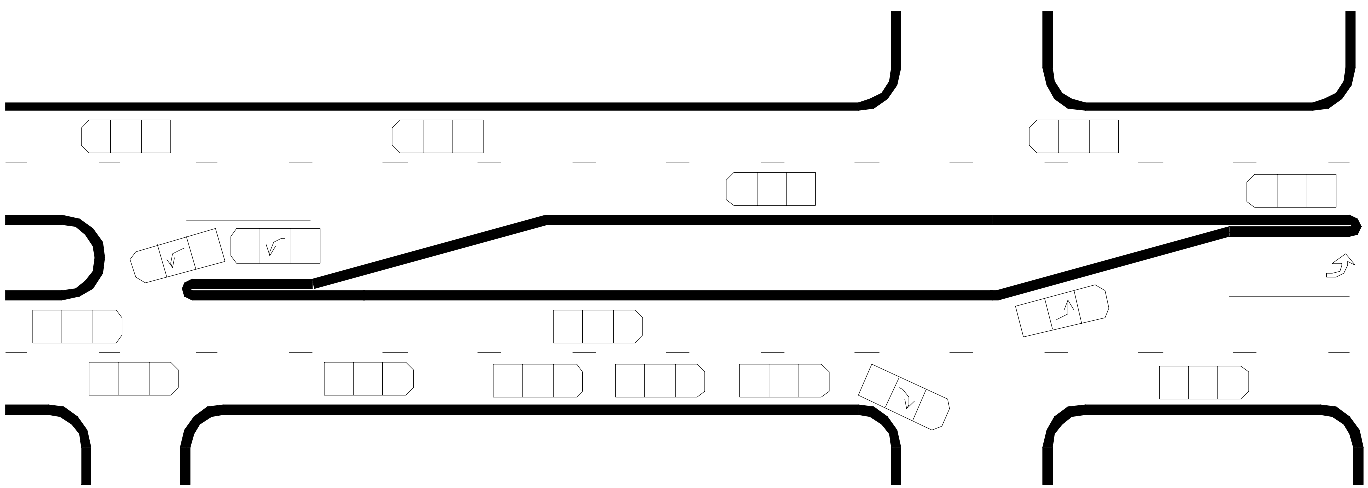
Conclusion

5. Guidelines
6. Additional Reading

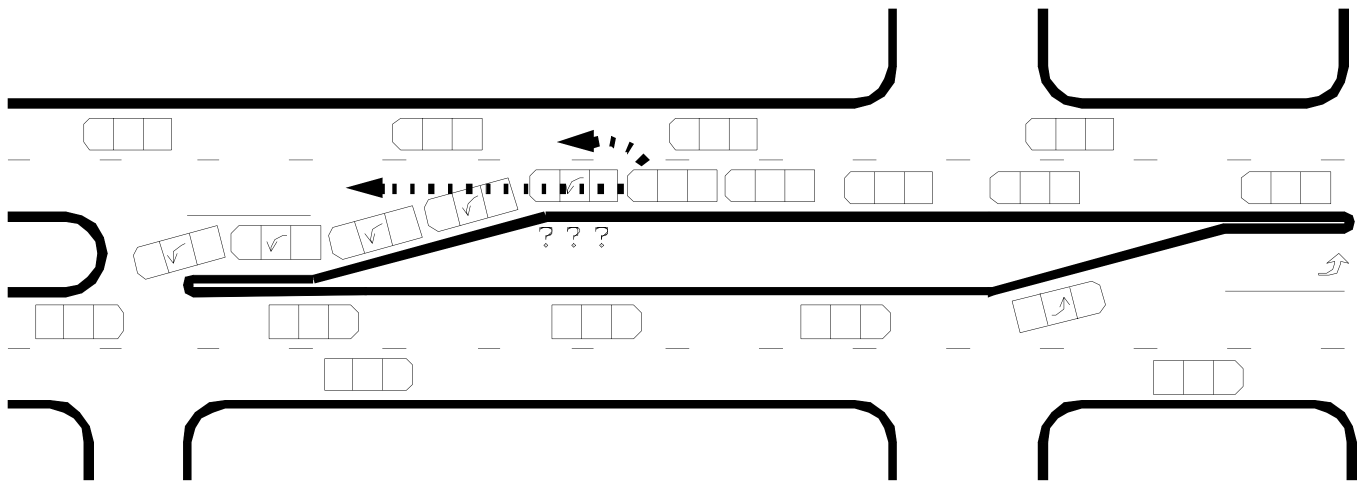
1. Operational Effects

- ✔ Delays due to right-turns from arterial
- ✔ Delays due to left-turns from arterial
- ✔ Delays due to high arterial volume
- ✔ Link spillback & resulting impedance
- ✔ Others: platoons, lane utilization, u-turns...

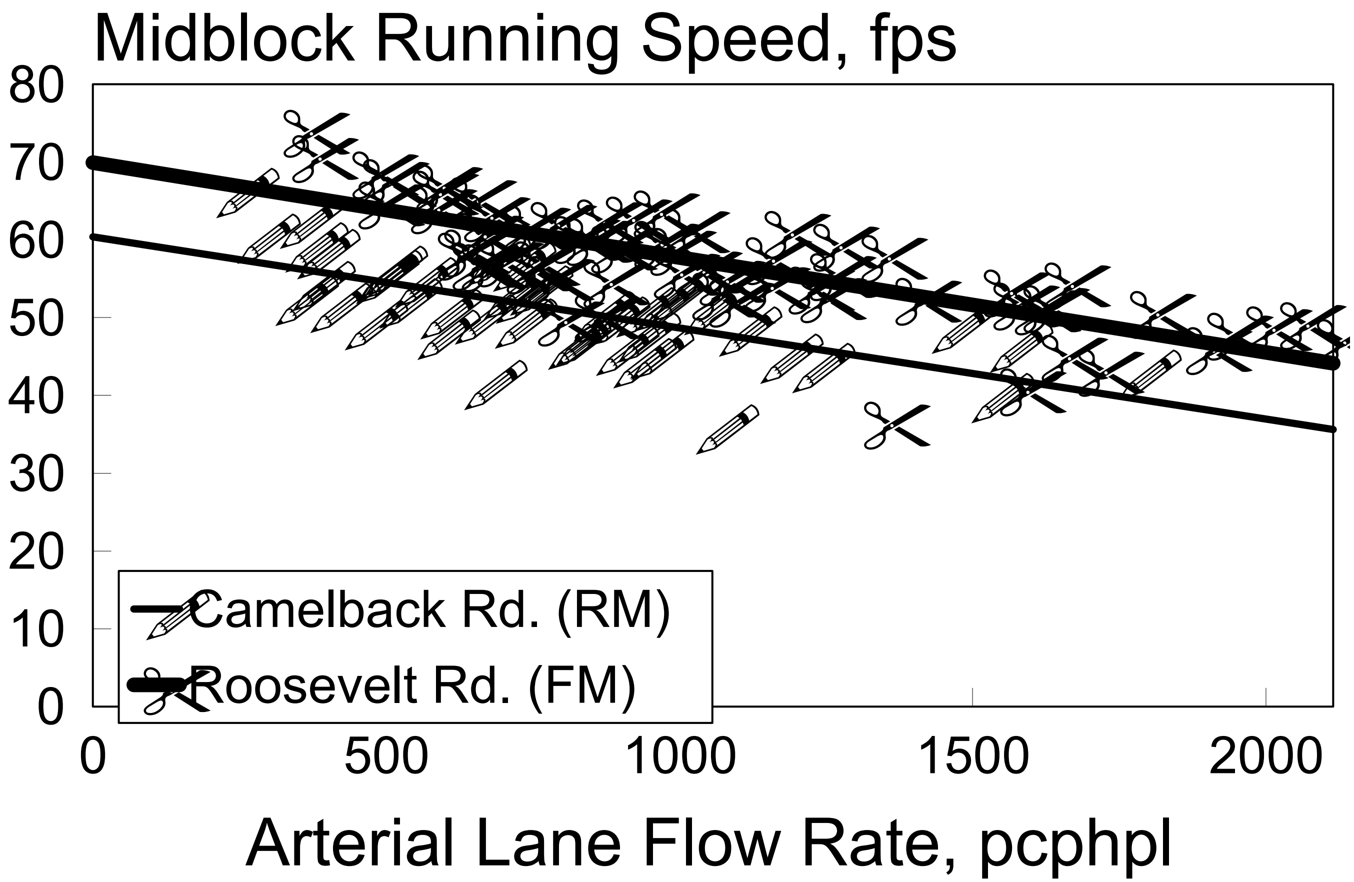
☹ Delays due to right-turns from arterial



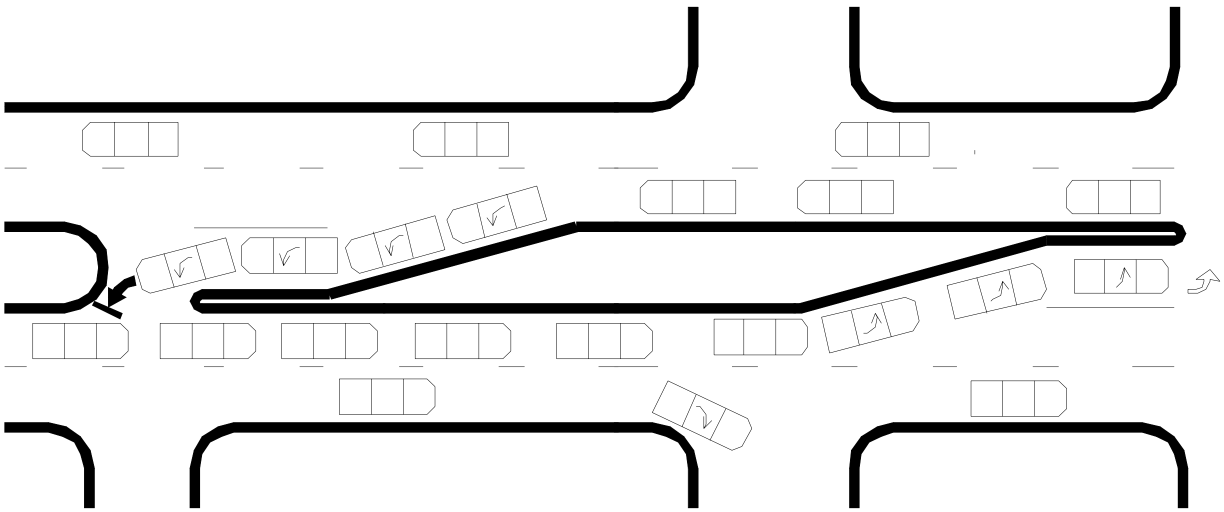
☹ Delays due to left-turns from arterial



☹ Delays due to high arterial volume



☹ Link spillback & resulting impedance



2. Operations Model

Input Data ➥
- volume
- geometry
- (T-7F)

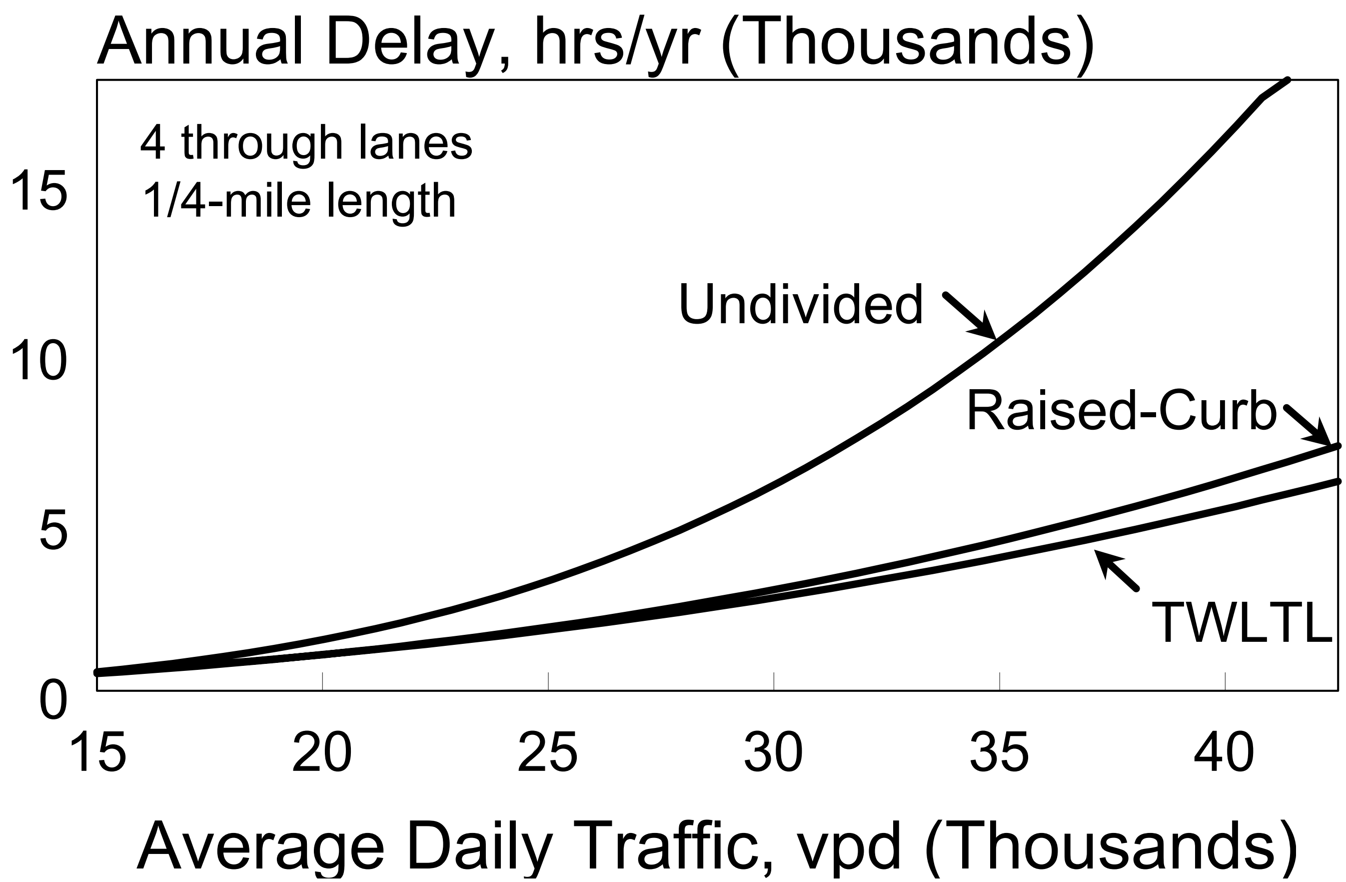
TWLTL-MAC

➥ **Output Data**
- capacity
- delay
- queue

Model Calibration Data:

- 32 studies in 4 states -- 160 hours
- Data: lane volume, capacity, queue length
- Tape switch sensors & video cameras

2. Operations Model



3. Safety Effects

- ✓ Raised-median has fewest accidents
- ✓ TWLTL safer than Undivided at higher ADT's
- ✓ Accidents more frequent with:
  - ! Higher access point density
  - ! Business or Office areas
  - ! Parallel parking

4. Safety Model

Six Regression Equations:

RC, TWLTL, Und.

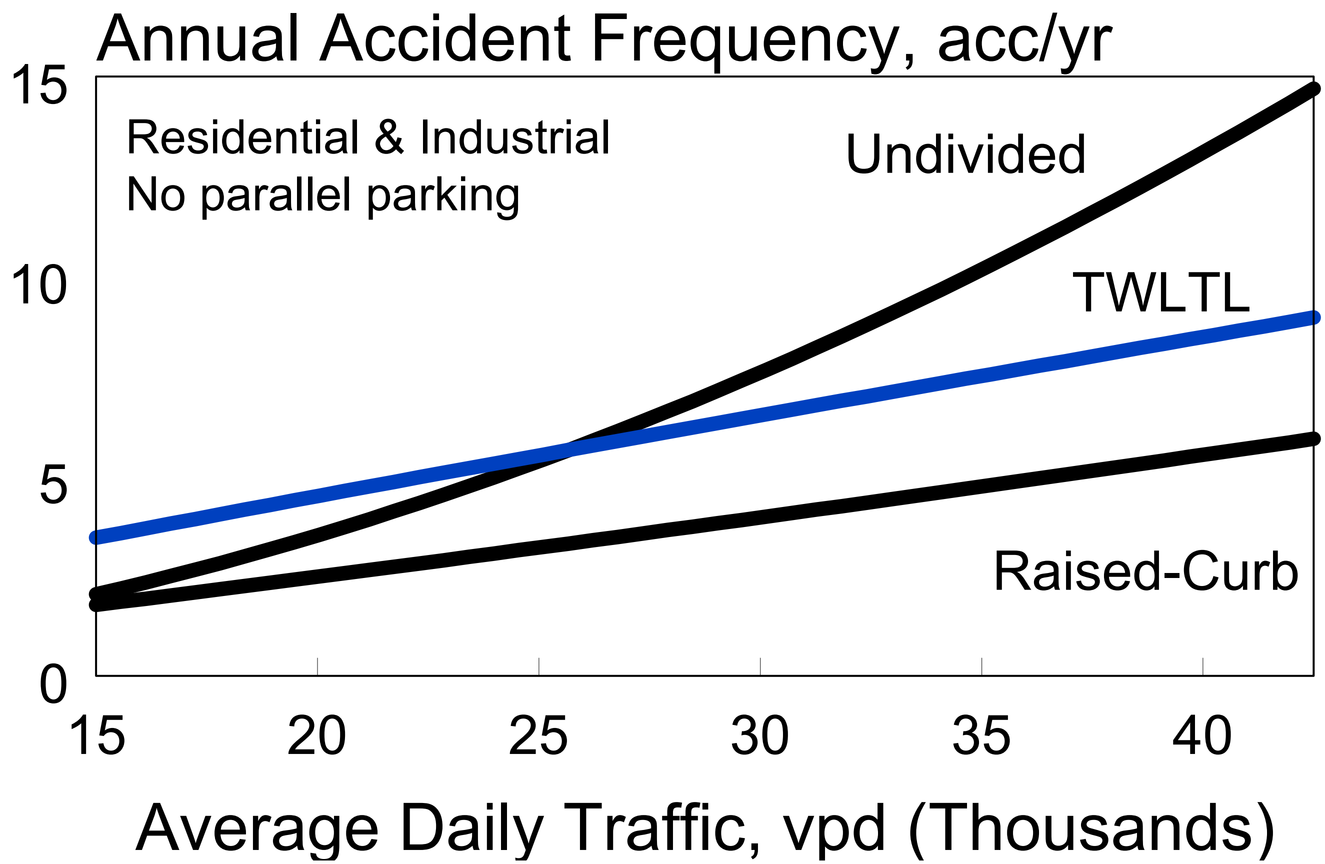
Business & Office, Residential & Industrial

$$A_U = ADT^{0.910}\, Len^{0.852}\, e^{(-14.15\ +\ 0.570\, I_{Park}\ +\ 0.0077\, (DD\ +\ SD)\ +\ 0.0255\, PDO)}$$

Model Calibration Data:

- Omaha, NE & Phoenix, AZ -- 3 years
- 6,391 accidents on 189 street segments

4. Safety Model



5. Guidelines

Undivided to Raised-Curb Median

ADT	Access Density	Left-Turn Percent					
		0	5	10	15	20	30
17,500	30	U	U	U	U	U	
	60	U	U	U			
22,500	30	U					R
	60						R
27,500	30			R	R	R	R
	60			R	R	R	R
32,500	30		R	R	R	R	R
	60		R	R	R	R	R

6. Additional Reading...

- ☛ NCHRP Report 395:

  Capacity and Operational Effects of Midblock Left-Turn Lanes

- ☛ ITE Journal, March, 1998:

  Median Treatment Selection for Existing Arterial Streets

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The topic of my presentation today is the Operational and Safety Effects of Alternative Median Treatments.

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The thoughts and ideas that I want to share with you today came from a recently completed research project that was conducted by myself and Pat McCoy at the University of Nebraska.

This project was funded by the National Cooperative Highway Research Program and titled "Capacity and Operational Effects of Midblock Left-Turn Lanes." The objective of this project was to develop a quantitative methodology for evaluating median treatments commonly used on urban and suburban arterials. The methodology was to consider the effect of median treatment on traffic operations, traffic safety, and access to adjacent properties. The median treatments we considered were the: raised-curb median, two-way left-turn lane, and the undivided cross section.

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In the next 15 minutes, I am going to describe some of the findings related to our research into the operational and safety effects of alternative median treatments. I am going to skip the discussion of access impacts; however, I would like to note that our findings in this regard are included in the project's final report.

First, I will give you a brief overview of the operational and safety effects; then I plan to mention the nature of the models we developed for the evaluation of each effect; and finally, I will wrap up by showing you the type of guidelines we developed and point you toward some printed materials where you can find more information on this topic.

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As a result of a literature review, survey of practitioners, and pilot field study, we identified numerous operational impacts that were related to the type of median treatment. The first three of these impacts represent delays to arterial through drivers. The fourth impact is more of an operational problem that leads to additional delays to all drivers entering, exiting, or traveling through the arterial. I will talk more about these four effects in the next few slides.

Before leaving this slide, I should note that there are many additional driver behaviors (such as platoon, lane utilization, u-turns, merging, etc. etc.) that can influence median treatment effects. These behaviors must also be quantified or modeled in order to accurately evaluate the relative merits of alternative median treatments. From my experience, existing software models (such as NETSIM or TRANSYT-7F) do not have sufficient sensitivity to these behaviors to yield accurate comparisons among alternative treatments.

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This illustration represents a plan view of a short section of arterial with vehicles moving along it in both directions. The effect shown here relates to the right-turning vehicle in the outside lane of the eastbound direction (i.e., left-to-right).

The speed-reduction associated with this right-turn can cause some delay to following through vehicles. The amount of delay per vehicle at any one location is relatively small; however, the this delay can be significant in terms of total vehicle-hours if you consider the large number of through vehicles affected on a busy arterial with frequent access points.

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Left-turn vehicles that block the inside through lane can cause significant delay to through vehicles on the unsignalized intersection approach. This blockage occurs most frequently on an undivided cross section but can occur for the raised-curb median when the storage bays are relatively short.

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The speed and volume data shown here were collected on two arterials–one has a raised-curb median and the other has a flush painted median. The trend shown is one of decreasing speed with increasing flow rate. There is also some suggestion that the flush median is associated with higher speeds than the raised-curb median.

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Two intersections can have an adverse affect on one another's operation if one of their left-turn queues is relatively long.   The drawing here shows the eastbound left-turn at the right intersection spilling back into the upstream intersection. This spillback represents an additional impedance to the westbound left-turn movement.

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Models for evaluating of all of the aforementioned operational effects were developed and combined into a larger model of arterial traffic flow. The larger model is referred to as the Operations Model; its software representation is called TWLTL-MAC.

Inputs to the Operations Model include the arterial turn movement counts, access point location, and cross section. Model outputs include capacity, delay, probability of bay overflow, and queue length for all traffic movements at each intersection as well as the arterial through movement travel speed. To take advantage of existing preprocessing software, TWLTL-MAC was written to read input files using the TRANSYT-7F input file format.

A considerable field study effort was undertaken to obtain the data needed to calibrate the Operations Model. Tape switches were used for temporary speed traps and video cameras were used to monitor queue lengths and gap acceptance.

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The left-turn and through movement delays obtained from the operations model were used to compute the annual delay incurred by these movements along a quarter-mile street segment (i.e. 1,320-ft between signals). The results of this aggregation are shown in this graph.

The trends shown in this graph suggest that the undivided cross section is associated with significantly higher delay than either the raised-curb median or TWLTL. The raised-curb median treatment has slightly higher delay than the TWLTL treatment at the highest left-turn and through volume ranges. This trend is due to the greater likelihood of bay overflow for the raised-curb treatment under high-volume conditions.

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. A review of the literature revealed that a large number of studies have been conducted to identify the safety differences among median treatments. The general consensus of the literature was that the undivided cross section is associated with more accidents than the TWLTL and raised-curb median. Our research tends to confirm this trend. Specifically, we found that the raised-curb median was associated with the fewest accidents. We also found that the TWLTL was safer than the Undivided cross section when daily traffic volumes were moderate to high.

Other factors having an influence on accident frequency include access point density, land use, and parking. We found that accidents were more frequent with higher access density, business or office areas, and those streets having parallel parking.

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The safety model is represented by six regression equations. One equation for each combination of three median types and two land use types.

Each equation predicts the expected annual accident frequency for a street segment based on its length, average daily traffic demand, and access point density. One of the six equations is shown here to illustrate is formulation.

The safety model was calibrated using data from the cities of Omaha, Nebraska and Phoenix, Arizona. The database represents 189 street segments that experienced 6,391 mid-signal accidents during a three-year period.

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The safety model was used to predict the expected annual accident frequency for a quarter-mile segment of arterial street (i.e., 1,320-ft between signals). This street was assumed to have 65 total access points per mile and no parallel parking. The predicted annual accident frequency for the three median types is shown in this graph.

One trend suggested by this graph is that accident frequency is higher on streets with an undivided cross section than those with a TWLTL. However, this is true only when the ADT exceeds about 25,000 veh. per day. The other trend suggested here is that the raised-curb median has the lowest accident frequency.

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The operations and safety models were used to develop tabular guidelines for converting from one median treatment to another. The delays and accidents predicted by these models were used to compute the road user benefit associated with a change in median treatment. This benefit was then compared to the construction cost associated with the treatment conversion. Arterial conditions that were (and were not) found to be cost-effective were identified in the selection guidelines.

The resulting guidelines for conversion from an undivided cross section to a raised-curb median on a four-lane arterial streets in business and office areas are shown here. All total, six tables were created and published in the project's final report.

To use this table, you locate the cell that most closely matches the access point density and traffic demand conditions that will exist for the design year. One of three recommendations are made, depending on the shading of the located cell. One recommendation is: "Stay with the existing treatment"; this recommendation is denoted by the gray shaded area.. A second recommendation is: "Consider adding [the alternative treatment];" this recommendation is denoted by the white area. A third recommendation is "Site-specific examination is needed;" this recommendation is denoted by the checker-board area. This recommendation is made when the benefits and costs associated with the conversion are nearly equal.

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If you are interested in learning more about our research findings or obtaining the guidelines, I would invite you to pick up a copy of NCHRP Report 395. This report is available from the Transportation Research Board.

You can also find a little more detail in a paper that I published in the ITE Journal last March. This paper represents a brief summary of the main findings of the research project.

That concludes my presentation, if you have any questions .... I would be happy to answer them.